2016 Korea-US Air Quality Study (KORUS-AQ)

What:

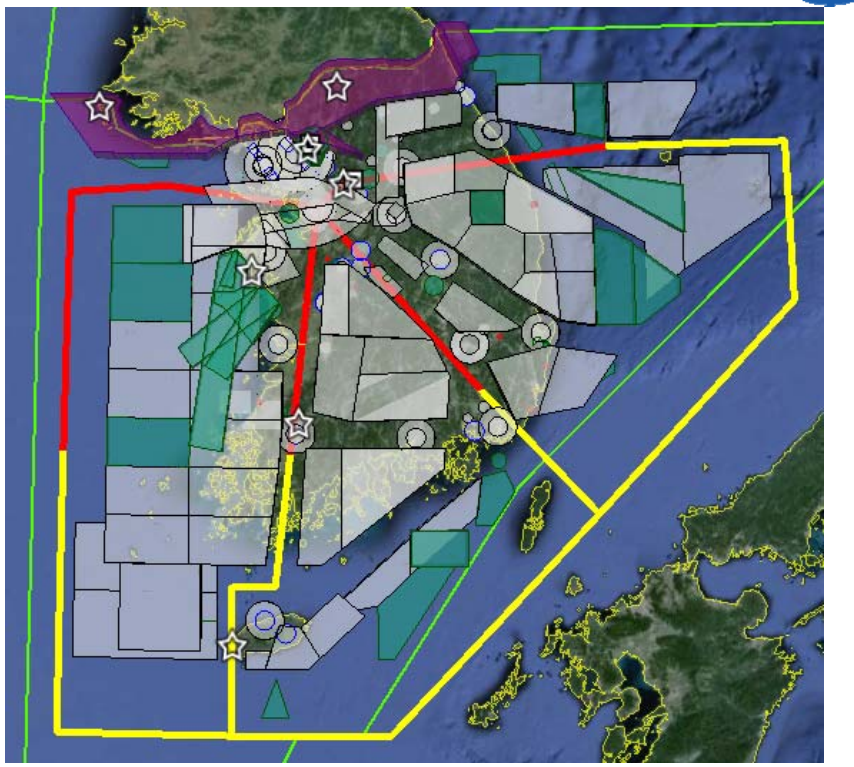
- **A co-operative intensive airborne, ground, and satellite field study being planned for a 6-week period within April-June 2016**
- **Focus on Korean peninsula and adjacent waters**

Why:

- **Readiness for geostationary satellite observability of air quality – trace gases and aerosols**
- **Megacity pollution – Model evaluation of Emissions, Chemistry, Transport**
- **Anthropogenic/Biogenic Mixtures**
- **Transboundary pollution**
- **Capacity building**

Components:

- **NASA DC-8 with in-situ and remote payload**
- **Korean B-200 partner aircraft**
- **Ground sites including the Korean Air Quality network and 5 research supersites**



Notional flight planning map illustrating the feasibility of conducting intensive airborne air quality surveys in Korea

Participants:

- **Korea Ministry of Environment, National Institute of Environmental Research, and Universities**
- **US NASA, NCAR, Universities, and possible other government agencies**

KORUS-AQ Study Status

- **Individual Korean and US White Papers defining objectives and priorities are available:**
  https://espo.nasa.gov/home/korus-aq/content/KORUS-AQ_Science_Overview_0

- **NIER and NASA have both approved funding for 2016 campaign**
  - NASA is soliciting proposals for instrumentation and theory teams with Element A.19 of ROSES 2015 Announcement of Opportunity
  - NIER is also funding a May-June 2015 pre-campaign
  - AERONET and Pandora remote sensing instruments will be deployed for 1 year at 6 sites beginning May 2015 to provide additional context/continuity

- **Joint Working Group is now developing implementation plan**
  - Operations will be conducted from Osan Airbase
  - Next working group meeting in June
  - Establish priorities for synergistic activities (such as addition of additional remote sensors to in-situ sites)

- **S5P early validation activity (pending S5P launch date)**

Options for DC-8 Payload (1 of 3: In-situ trace gas)

In-Situ Trace Gas Measurements	Technique(s)
O_3, NO, NO_2, NO_y	Chemiluminescence
CO, CH_4, N_2O	Diode Laser Spectroscopy
CO_2	Non-dispersive infrared spectrometry
H_2O	Diode Laser and Frost Point Hygrometers
Non-methane hydrocarbons	Whole Air Sampling, Proton Transfer Mass Spectrometry
CH_2O	Difference Frequency Generation Absorption Spectrometry, Laser Induced Fluorescence
H_2O_2, CH_3OOH	Chemical Ionization Mass Spectrometry
NO_2, Alkyl nitrates, Peroxy nitrates, HNO_3	Thermal Dissociation – Laser Induced Fluorescence
HNO_3	Chemical Ionization Mass Spectrometry, Mist Chamber-Ion Chromatography
Speciated PANs, SO_2	Chemical Ionization Mass Spectrometry
Isoprene and oxidation products	Chemical Ionization Mass Spectrometry and Proton Transfer Mass Spectrometry

In-situ profile measurements along with remote-sensing retrievals

Options for DC-8 Payload (2 of 3: In-situ aerosol)

In-situ Aerosol Measurements	Technique(s)
Aerosol number and size distributions	Optical and Aerodynamic Particle Counters, CCN counter
Aerosol Scattering and Absorption	Nephelometry, Cavity Ringdown Extinction Spectroscopy, Photoacoustic Absorption Spectroscopy
Aerosol Composition	Bulk Filters, Aerosol Mass Spectrometry, Single Particle Laser Mass Spectrometry
Black Carbon	Single Particle Soot Photometer (dry and humidified)
Size-resolved Hygroscopicity	Differential aerosol sizing and hygroscopicity spectrometer
Cloud Particle Imaging	Forward Scattering Spectrometer Probe and 2D-S

In-situ profile measurements along with remote-sensing retrievals

Options for DC-8 Payload (3 of 3: Remote Sensing)

Remote Sensing	Technique(s)
Ozone vertical profile (zenith and nadir)	Differential Absorption Lidar
Aerosol scattering, extinction, and depolarization profile (zenith and nadir)	High Spectral Resolution Lidar
Multi-spectral trace gas column maps*	**Nadir UV-Vis push-broom spectrometer**
Multi-spectral aerosol optical depth and trace gas columns	Sun-tracking spectrometer
Molecular photolysis frequencies	UV Actinic Flux Spectroradiometry
Spectrally-resolved Solar and Broadband Solar and IR Irradiance	Solar Spectral Flux Radiometry, Solar and IR Broadband Radiometry

Airborne simulator for TEMPO and GEMS

In-situ profile measurements along with remote-sensing retrievals

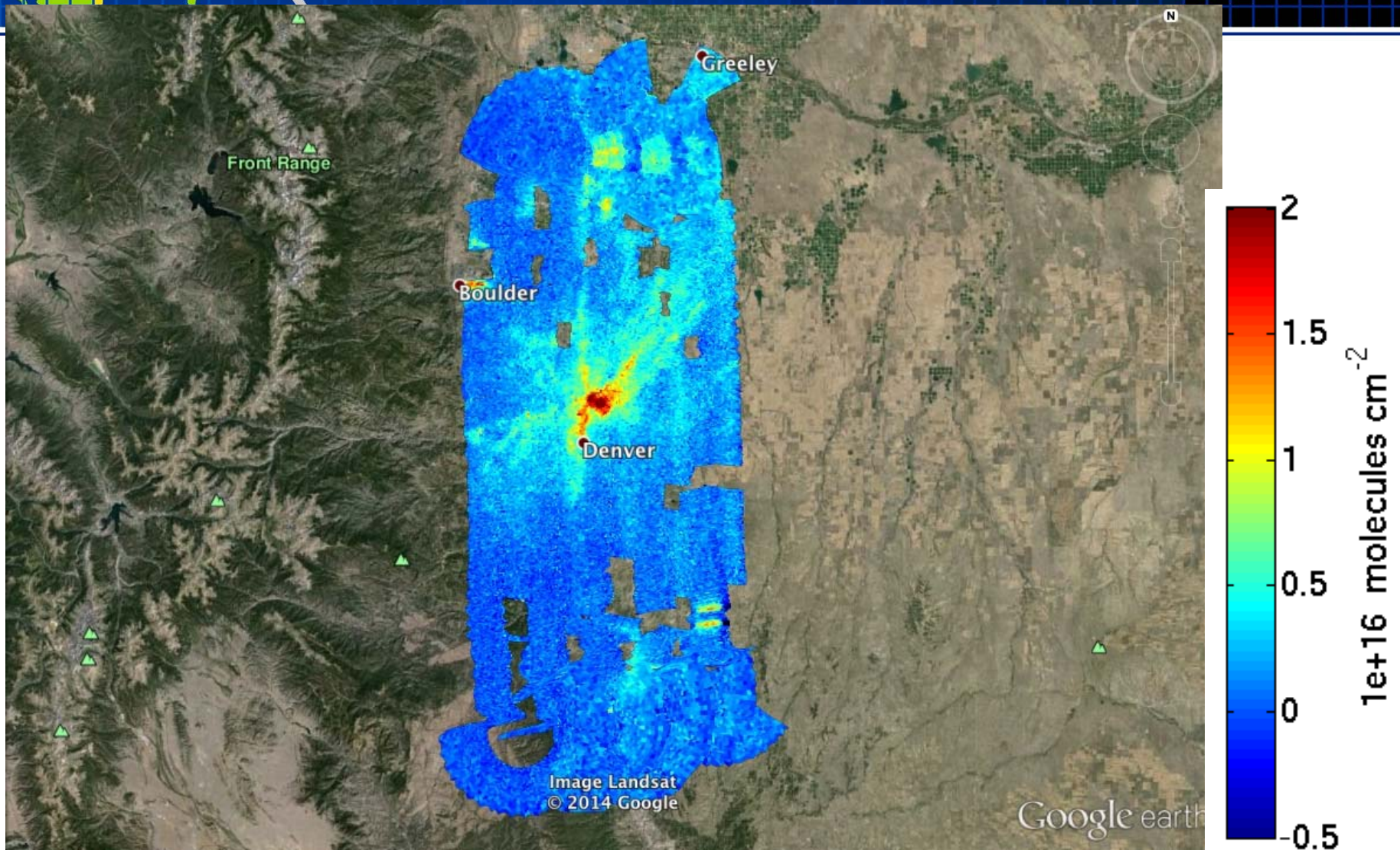
Overview of GeoTASO (TEMPO/GEMS Airborne Simulator)

- **NASA-funded airborne sensor and trace gas/aerosol retrieval project to advance mission readiness of sensor/algorithms for TEMPO mission**
  - **Sensor is a 2 channel UV-Vis spectrometer covering 290-390 and 415-695 nm**
    - **Imaging spectrometer covers ~8 km swath with 50 m x 80 m ground patch resolution**
    - **Spectral passbands of ~ 0.4 nm in UV, ~0.8 nm in Vis with 3x oversampling spectrally**
    - **Signal to noise of ~ 50 for individual samples**
  - **Project status**
    - **Sensor built and demonstrated on Falcon aircraft during 2 DISCOVER-AQ deployments**
    - **Retrievals using flight data underway**
    - **Sensor calibration at GSFC before and after deployments**

- **DISCOVER-AQ flights**
  - **20 flight hours during Sep. 2013 Houston deployment**
  - **50 flight hours during July-Aug 2014 Denver deployment**
  - **Most flights at ~35 kft altitude and overfly DISCOVER-AQ sites**
  - **Retrievals of atmospheric pollutants from flight data**
    - **Trace gas retrievals typically use binned up samples at 0.5 to 1 km square cells**
    - **NO2 and AOD retrievals demonstrated**
    - **SO2, NO2, CHCO, CHOCHO retrieval products in development**
    - **Ozone retrieval using both UV and Vis absorption bands in development**

GeoTASO NO_2 Slant Column, 02 August 2014

Morning



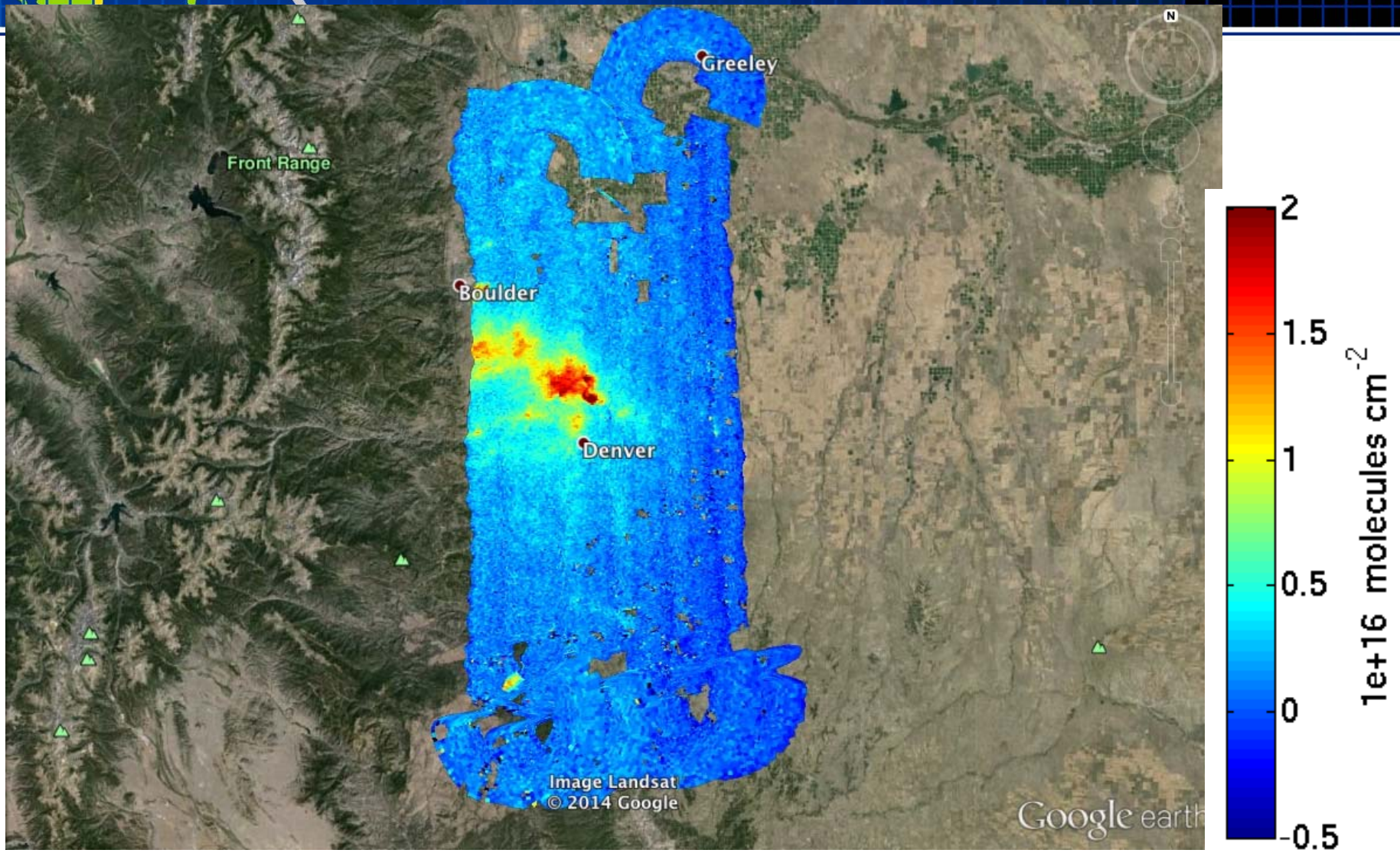
Co-added to approx. 500m x 450m

Morning vs. Afternoon

Preliminary data

GeoTASO NO_2 Slant Column, 02 August 2014

Afternoon



Co-added to approx. 500m x 450m

Morning vs. Afternoon

Preliminary data

Summary of KORUS-AQ

Satellite observability of air quality – trace gases and aerosols

- Including integration with models and ground monitoring networks
- Supports ongoing development of retrieval algorithms for GEO missions
- Validation strategy testbed for GEO (TEMPO, GEMS, Sentinel-4) missions
- Possible early validation of low Earth orbit TROPOMI (Sentinel-5 precursor) mission
- Readiness for air quality community to use geostationary AQ observations at launch

Compelling science

- Megacity pollution – Model evaluation of Emissions, Chemistry, Transport
- Impacts of Anthropogenic/Biogenic Mixtures on secondary pollution formation (ozone and aerosols)
- Transboundary pollution – Local sources versus upwind along the Pacific Rim
- Confirm Asian emission trends

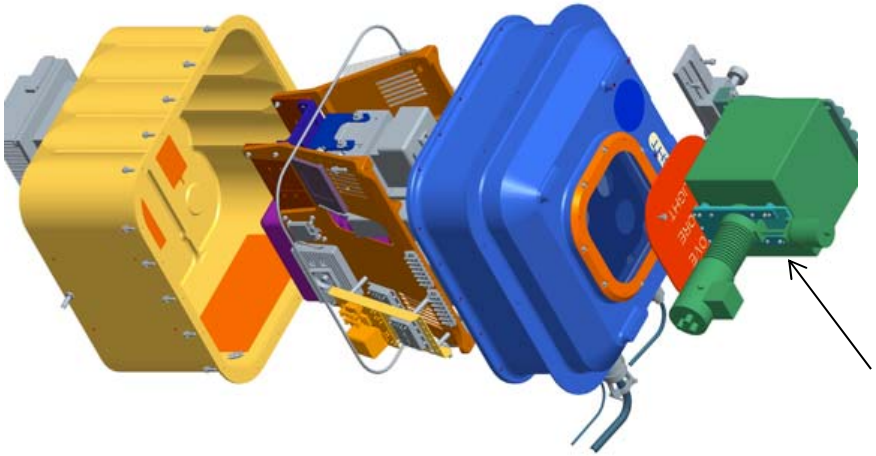
On schedule for 6-week campaign during April-June 2016

Collaborative KORUS-AQ airborne field campaign offers excellent opportunity for ongoing GEO AQ mission preparation and S-5P (TROPOMI) early validation

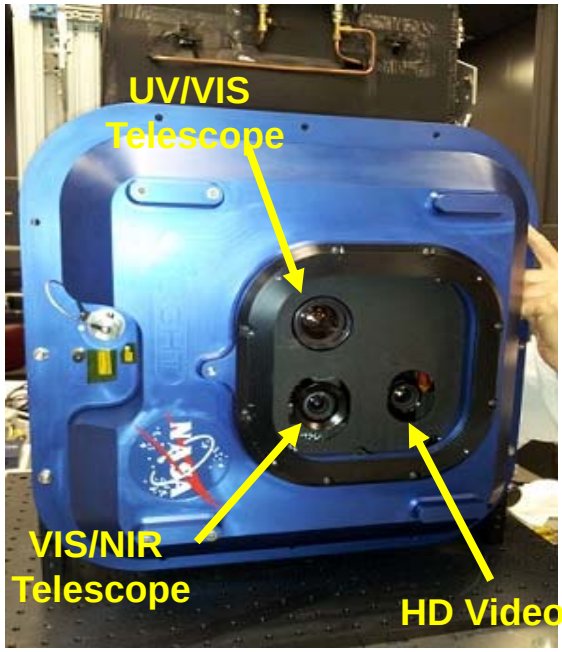
Backup

Overview of GCAS (TEMPO/GEMS Airborne Simulator)

Exploded view



Field Radiometric Calibration Fixture



Telescopes map vertical slit extent to a 7.5 km cross-track FOV. Images captured at 2 Hz and co-added along track.

Spectral coverage and sampling

- **300-490 nm @0.2 nm/pixel**
- **480-890 nm @0.4 nm/pixel**

Slant column product precision for NO_2

•Minimum retrieved resolution 250 m x 500 m: 1.5e15 molecules cm^{-2}

•Typical retrieved resolution 1 km x 1.5 km: 0.4e14 molecules cm-2

Retrievals for total O3 and HCHO have also been demonstrated